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Water level manipulations are one of the most effective tools in wetland management, provided fluctuations are well-timed and controlled. Manipulations are most effective on sites with (1) a dependable water supply, (2) an elevation gradient that permits complete water coverage at desired depths over a majority of the site, and (3) the proper type of water control structures that enable water to be supplied, distributed, and discharged effectively at desired rates. The size and location of structures are important, but timing, speed, and duration of drawdowns and flooding also have important effects on plant composition, plant production, and avian use. When optimum conditions are not present, effective moist-soil management is still possible, but limitations must be recognized. Such situations present special problems and require particularly astute and timely water level manipulations. For example, sometimes complete drainage is not possible, yet water is usually available for fall flooding. In such situations, management can capitalize on evapotranspiration during most growing seasons to promote the germination of valuable moist-soil plants.

Timing of Drawdowns

Drawdowns often are described in general terms such as early, midseason, or late. Obviously, calendar dates for a drawdown classed as early differ with both latitude and altitude. Thus the terms early, midseason, and late should be considered within the context of the length of the local growing season. Information on frost-free days or the average length of the growing season usually is available from agricultural extension specialists. Horticulturists often use maps depicting different zones of growing conditions (Fig. 1). Although not specifically developed for wetland management, these maps provide general guidelines for estimating an average growing season at a particular site.

In portions of the United States that have a growing season longer than 160 days, drawdowns normally are described as early, midseason, or late. In contrast, when the growing season is shorter than 140 days, drawdown dates are better described as either early or late. Early drawdowns are those that occur during the first 45 days of the growing season, whereas late drawdowns occur in the latter 90 days of the growing season. For example, the growing season extends from mid-April to late October (200 days) in southeastern Missouri. In this area, early drawdowns occur until 15 May, midseason drawdowns occur between 15 May and 1 July, and late drawdowns occur after 1 July (Table 1). The

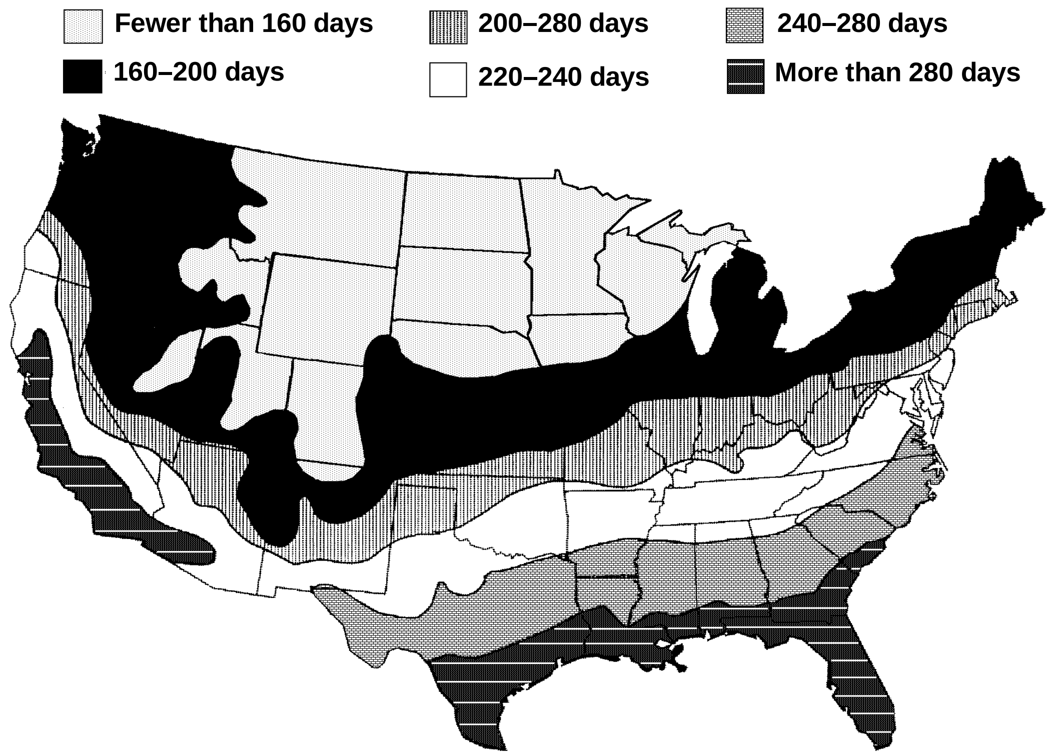

Fig. 1. Zones depicting general differences in the length of the growing season.

correct terminology for drawdown date can be determined for each area using these rules of thumb.

Moist-soil Vegetation

The timing of a drawdown has an important influence on the composition and production of moist-soil plants. Although the importance of specific factors resulting in these differences has not been well studied for moist-soil vegetation, factors such as seed banks, soil types, soil temperatures, soil moisture levels, soil–water salinities, day length, and residual herbicides undoubtedly influence the composition of developing vegetation.

Water manipulations will be effective and economical only if the site has been properly designed and developed (Table 2). Levees, type and dependability of water source (e.g., ground water, river, reservoir), type and placement of water control structures, water supply and drainage systems, and landform are among the most important elements that must be considered. Independent control and timing of water supply, distribution, depth, and discharge within and among units are essential (Table 2).

An independent water supply for each unit is required to optimize food production, maintain the potential to control problem vegetation, and make food resources available for wildlife (Table 2). Optimum management also requires that each unit have the capability of independent discharge. Stoplog water control structures that permit water level manipulations as small as 2 inches provide a level of fine tuning that facilitates control of problem vegetation or enhancement of desirable vegetation.

Table 1. *Environmental conditions associated with time of drawdown in southeastern Missouri.*

	Date	Temperature	Rainfall	Evapotranspiration
Early	1 April–15 May	Moderate	High	Low
Mid	15 May–1 July	Moderate–High	Moderate	Moderate
Late	1 July or later	High	Low	High

Table 2. *Important considerations in evaluating wetland management potential.*

Factors	Optimum condition
Water supply	Independent supply into each unit Water supply enters at highest elevation
Water discharge	Independent discharge from each unit Discharge at lowest elevation for complete drainage Floor of control structure set at correct elevation for complete drainage
Water control	Stoplog structure allowing 2-inch changes in water levels Adequate capacity to handle storm events
Optimum unit size	5 to 100 acres
Optimum number of units	At least 5 within a 10-mile radius of units

Wetland systems with high salinities can easily accumulate soil salts that affect plant vigor and species composition. Wetland unit configurations that allow flushing of salts by flowing sheet water across the gradient of a unit are essential in such areas. A fully functional discharge system is a necessity in arid environments to move water with high levels of dissolved salts away from intensively managed basins. Thus, successful management in arid environments requires units with an independent water supply and independent discharge as well as precise water-level control.

Scheduling Drawdowns

During most years, early and midseason drawdowns result in the greatest quantity of seeds produced (Table 3). However, there are exceptions, and in some cases, late drawdowns are very successful in stimulating seed production.

Table 3. *Response of common moist-soil plants to drawdown date.*

	Species		Drawdown date		
Family	Common name	Scientific name	Early[a]	Midseason[b]	Late[c]
Grass	Swamp timothy	*Heleochloa schoenoides*	+[d]	+++	+
	Rice cutgrass	*Leersia oryzoides*	+++	+	
	Sprangletop	*Leptochloa* sp.		+	+++
	Crabgrass	*Digitaria* sp.		+++	+++
	Panic grass	*Panicum* sp.		+++	++
	Wild millet	*Echinochloa crusgalli* var. *frumentacea*	+++	+	+
	Wild millet	*Echinochloa walteri*	+	+++	++
	Wild millet	*Echinochloa muricata*	+	+++	+
Sedge	Red-rooted sedge	*Cyperus erythrorhizos*		++	
	Chufa	*Cyperus esculentus*	+++	+	
	Spikerush	*Eleocharis* spp.	+++	+	+
Buckwheat	Pennsylvania smartweed	*Polygonum pensylvanicum*	+++		
	Curltop ladysthumb	*Polygonum lapathifolium*	+++		
	Dock	*Rumex* spp.		+++	+
Pea	Sweetclover	*Melilotus* sp.	+++		
	Sesbania	*Sesbania exalta*	+	++	
Composite	Cocklebur	*Xanthium strumarium*	++	+++	++
	Beggarticks	*Bidens* spp.	+	+++	+++
	Aster	*Aster* spp.	+++	++	+
Loosestrife	Purple loosestrife	*Lythrum salicaria*	++	++	+
	Toothcup	*Ammania coccinea*	+	++	++
Morning glory	Morning glory	*Ipomoea* spp.	++	++	
Goosefoot	Fat hen	*Atriplex* spp.	+++	++	

[a] Drawdown completed within the first 45 days of the growing season.
[b] Drawdown after first 45 days of growing season and before 1 July.
[c] Drawdown after 1 July.
[d] + = fair response; ++ = moderate response; +++ = excellent response.

In areas characterized by summer droughts, early drawdowns often result in good germination and newly established plants have time to establish adequate root systems before dry summer weather predominates. As a result, early drawdowns minimize plant mortality during the dry period. Growth is often slowed or halted during summer, but when typical late growing-season rains occur, plants often respond with renewed growth and good seed production. In contrast, midseason drawdowns conducted under similar environmental conditions often result in good germination, but poor root establishment. The ultimate result is high plant mortality or permanent stunting. If the capability for irrigation exists, the potential for good seed production following midseason or late drawdowns is enhanced.

Germination of each species or group of species is dependent on certain environmental conditions including soil temperature and moisture. These conditions change constantly and determine the timing and density of germination (Table 3). Smartweeds tend to respond best to early drawdowns, whereas sprangletop response is best following late drawdowns. Some species are capable of germination under a rather wide range of environmental conditions; thus, control of their establishment can be difficult. Classification of an entire genera into a certain germination response category often is misleading and inappropriate. For example, variation exists among members of the millet group (*Echinochloa* spp.). *Echinochloa frumentacea* germinates early, whereas *E. muricata* germinates late because of differences in soil temperature requirements. Such variation among members of the same genus indicates the need to identify plants to the species level.

Natural systems have flooding regimes that differ among seasons and years. Repetitive manipulations scheduled for specific calendar dates year after year often are associated with declining productivity. Management assuring good production over many years requires variability in drawdown and flooding dates among years. See *Fish and Wildlife Leaflet* 13.2.1 for an example of how drawdown dates might be varied among years.

Wildlife Use

Drawdowns serve as an important tool to attract a diversity of foraging birds to sites with abundant food resources. Drawdowns increase food availability by concentrating foods in smaller areas and at water depths within the foraging range of target wildlife. A general pattern commonly associated with drawdowns is an initial use by species adapted to exploiting resources in deeper water. As dewatering continues, these "deep water" species are gradually replaced by those that are adapted to exploit foods in

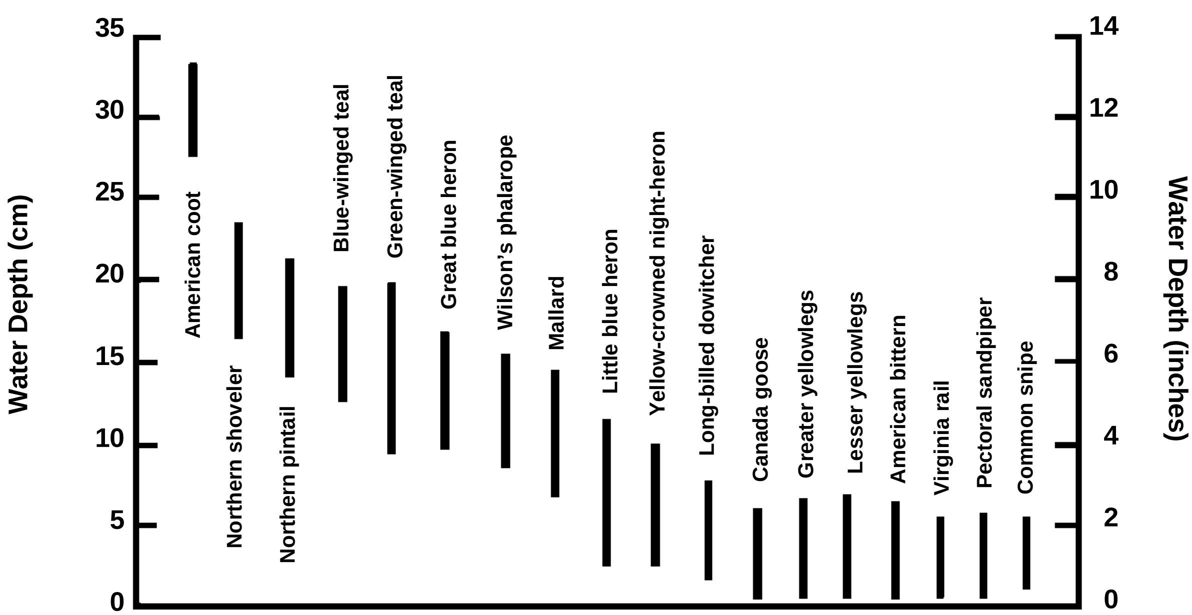

Fig. 2. Preferred water depths for wetland birds commonly associated with moist-soil habitats.

shallower water (Fig. 2). The most effective use of invertebrate foods by wetland birds occurs when drawdowns to promote plant growth are scheduled to match key periods of migratory movement in spring. By varying drawdown dates among units, the productivity of each unit can be maintained and resources can be provided for longer periods. Slow drawdowns also prolong use by a greater number and diversity of wetland wildlife.

Effects of Drawdown Rate

Moist-soil Plant Production

Fast Drawdowns

Sometimes fast drawdowns (1–3 days) are warranted, especially in systems with brackish or saline waters where the slow removal of water may increase the level of soil salts. However, in most locations fast drawdowns should only be scheduled early in the season or when flood irrigation is possible. Rapid drawdowns that coincide with conditions of high temperature and little rainfall during the growing season create soil moisture conditions that often result in poor moist-soil responses (Table 4). Some germination may occur, but generally development of root systems is inadequate to assure that these newly established plants survive during summer drought. Thus, at latitudes south of St. Louis, fast drawdowns are never recommended after 15 June if irrigation is not possible.

Slow Drawdowns

Slow drawdowns (2–3 weeks) usually are more desirable for plant establishment and wildlife use. The prolonged period of soil saturation associated with slow drawdowns creates conditions favorable for moist-soil plant germination and establishment (Table 4). For example, slow drawdowns late in the growing season can result in seed yields of 700 pounds per acre. Rapid drawdowns on adjacent units subject to identical weather conditions have resulted in 50 pounds per acre. Furthermore, slow drawdowns provide shallow water over a longer period, ensuring optimum foraging conditions for wildlife. If salinities tend to be high, slow drawdowns should only be scheduled during winter or early in the season when ambient temperatures and evapotranspiration are low.

Table 4. *Comparison of plant, invertebrate, bird, and abiotic responses to rate and date of drawdown among wet and dry years.*

	Drawdown rate	
	Fast[a]	Slow[b]
Plants		
Germination		
Period of ideal conditions	short	long
Root development		
Wet year	good	excellent
Dry year	poor	excellent
Seed production		
Early season	good	excellent
Mid–late season	not recommended	excellent
Wet year	good	good
Drought year	poor	good
Cocklebur production	great potential	reduced potential
Invertebrates		
Availability		
Early season	good	excellent
Mid–late season	poor	good
Period of availability	short	long
Bird use		
Early season	good	excellent
Mid–late season	poor	good
Nutrient export	high	low
Reducing soil salinities	good	poor

[a] Less than 4 days.
[b] Greater than 2 weeks.

Invertebrate Availability in Relation to Drawdowns

When water is discharged slowly from a unit, invertebrates are trapped and become readily available to foraging birds along the soil–water interface or in shallow water zones (Table 4). These invertebrates provide the critical protein-rich food resources required by pre-breeding and breeding female ducks, newly hatched waterfowl, molting ducks, and shorebirds. Shallow water for foraging is required by the vast majority of species; e.g., only 5 of 54 species that commonly use moist-soil impoundments in Missouri can forage effectively in water greater than 10 inches. Slow drawdowns lengthen the period for optimum foraging and put a large portion of the invertebrates within the foraging ranges of many species. See *Fish and Wildlife Leaflet* 13.3.3 for a description of common invertebrates in wetlands.

Spring Habitat Use by Birds

Slow drawdowns are always recommended to enhance the duration and diversity of bird use (Table 4). Creating a situation in which the optimum foraging depths are available for the longest period provides for the efficient use of food resources, particularly invertebrate resources supplying proteinaceous foods. Partial drawdowns well in advance of the growing season (late winter) tend to benefit early migrating waterfowl, especially mallards and pintails. Early-spring to mid-spring drawdowns provide resources for late migrants such as shovelers, teals, rails, and bitterns. Mid- and late-season drawdowns provide food for breeding waders and waterfowl broods. These later drawdowns should be timed to coincide with the peak hatch of water birds and should continue during the early growth of nestlings or early brood development.

Fall Flooding Strategies

Scheduling fall flooding should coincide with the arrival times and population size of fall migrants (Table 5). Sites with a severe disease history should not be flooded until temperatures

Table 5. *Water level scenario for target species on three moist-soil impoundments and associated waterbird response.*

	Unit A		Unit B		Unit C	
	Water level		Water level		Water level	
Period	Scenario	Response	Scenario	Response	Scenario	Response
Early fall	Dry	None	Dry	None	Gradual flooding starting 15 days before the peak of early fall migrants; water depth never over 4 inches	Good use immediately; high use by teal, pintails, and rails within 2 weeks
Mid fall	Dry	None	Flood in weekly 1–2-inch increments over a 4-week period	Excellent use by pintails, gadwalls, and wigeons	Continued flooding through September	Excellent use by rails and waterfowl
Late fall	Flood in weekly 2–4-inch increments over a 4–6-week period	Excellent use immediately by mallards and Canada geese	Continued flooding, but not to full functional capacity	Excellent use by mallards and Canada geese	Continued flooding to full functional capacity	Good use by mallards and Canada geese
Winter	Maintain flooding below full functional capacity	Good use by mallards and Canada geese when water is ice free	Maintain flooding below full functional capacity	Good use by mallards and Canada geese when water is ice free	Continued flooding to full pool	Good use by mallards and Canada geese when water is ice free
Late winter	Schedule slow drawdown to match northward movement of migrant waterfowl	Excellent use by mallards, pintails, wigeons, and Canada geese	Schedule slow drawdown to match northward movement of early migrating waterfowl	Excellent use by mallards, pintails, wigeons, and Canada geese	Schedule slow drawdown to match northward movement of waterfowl	Good use by mallards and Canada geese when water is ice free
Early spring	Continued slow drawdown to be completed by 1 May	Excellent use by teals, shovelers, shorebirds, and herons	Drawdown completed by 15 April	Excellent shorebird use	Drawdown completed by 15 April	Excellent shorebird use

moderate. When flooding is possible from sources other than rainfall, fall flooding should commence with shallow inundation on impoundments suited for blue-winged teals and pintails. Impoundments with mature but smaller seeds, such as panic grass and crabgrasses, that can be flooded inexpensively are ideal for these early migrating species. Flooding always should be gradual and should maximize the area with water depths no greater than 4 inches (Fig. 3). As fall progresses, additional units should be flooded to accommodate increasing waterfowl populations or other bird groups such as rails. A reasonable rule of thumb is to have 85% of the surface area of a management complex flooded to an optimum foraging depth at the peak of fall waterfowl migration.

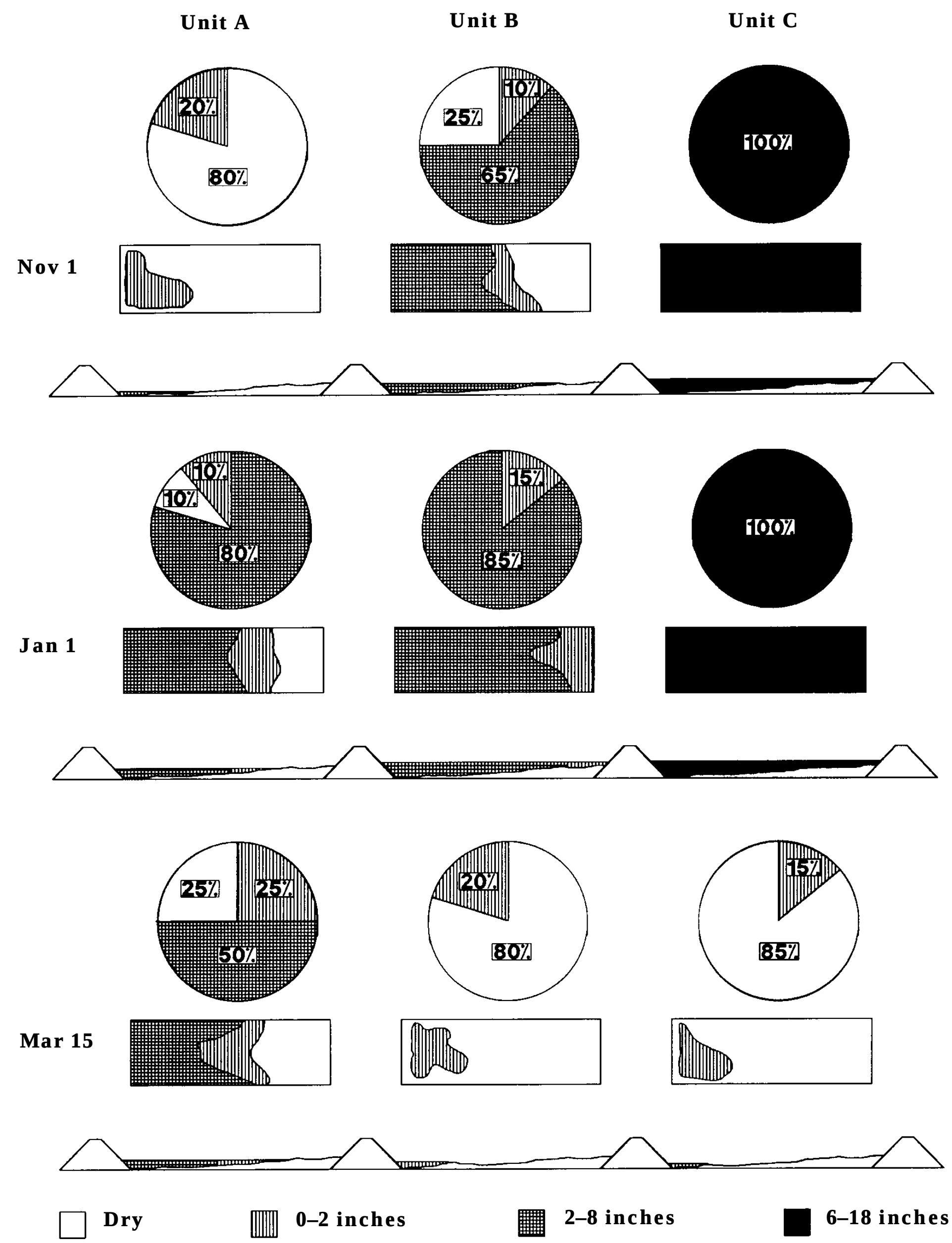

Fig. 3. Planned flooding strategies for three moist-soil units during one winter season. The initiation, depth, and duration of flooding are different for each unit. Note that two of the three units were never intentionally flooded to capacity. This does not mean that natural events would not flood the unit to capacity. Flooding strategies should be varied among years to enhance productivity.

Suggested Reading

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Appendix. Common and Scientific Names of Birds Named in Text.

Pied-billed grebe	*Podilymbus podiceps*
American bittern	*Botaurus lentiginosus*
Great blue heron	*Ardea herodias*
Little blue heron	*Egretta caerulea*
Yellow-crowned night-heron	*Nycticorax violaceus*
Tundra swan	*Cygnus columbianus*
Snow goose	*Chen caerulescens*
Canada goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Blue-winged teal	*Anas discors*
Canvasback	*Aythya valisineria*
Virginia rail	*Rallus limicola*
American coot	*Fulica americana*
Greater yellowlegs	*Tringa melanoleuca*
Lesser yellowlegs	*Tringa flavipes*
Pectoral sandpiper	*Calidris melanotos*
Long-billed dowitcher	*Limnodromus scolopaceus*
Wilson's phalarope	*Phalaropus tricolor*
Common snipe	*Capella gallinago*

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